



WATER RESOURCES RESEARCH GRANT PROPOSAL

Project ID: 2005KS40B

Title: A Real-Time Permittivity Sensor for Simultaneous Measurement of Multiple Water-Quality Parameters

Project Type: Research

Focus Categories: Water Quality

Keywords: water quality, permittivity, dielectric constant, conductivity, sensor, frequency-response method

Start Date: 03/01/2005

End Date: 02/28/2006

Federal Funds: \$30,000

Non-Federal Matching Funds: \$60,194

Congressional District: 2

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Abstract

Permittivity is the most important property of dielectric materials, such as water. Permittivity describes both conductive and dielectric (capacitive) properties of dielectric materials. Pollutants in water, including sediment, nutrients introduced by fertilizers, and pesticides, have different effects on the conductive and capacitive behaviors of water. Thus, effective measurement of conductive and capacitive parameters can be used to detect the existence and concentrations of various types of pollutants in water.

Existing permittivity sensors measure either the conductive, or the capacitive property of dielectric materials, but not both, mainly because these sensors operate at a single frequency. Some of these sensors were not designed for real-time, in-situ measurement.

Thus, they are not suitable for continuous real-time monitoring of water quality parameters that may vary substantially over short periods of time.

Since 2001, we have developed a novel permittivity sensor that is capable of measuring both the conductive and capacitive parameters of dielectric materials. Design of the sensor was based on the traditional four-electrode, Wenner-array structure. Modifications were made on the electrode geometry to enlarge the capacitive effect. Rather than using a single frequency, the sensor used multiple frequencies ranging from 1 Hz to 15 MHz to allow acquisition of multiple pieces of information. The sensor has been successfully tested on soil to simultaneously measure soil volumetric water content and salinity.

For the proposed research, we will further modify the sensor and associated electronics so that the sensor can be used for measurement of multiple water properties. Modification of the hardware will include extending the measurement frequency to 100 MHz and adding phase measurement. The sensor will also be redesigned to fit in-situ water quality monitoring applications. The use of a microcontroller in the system will allow real-time measurement.

The sensor will be tested in laboratory to measure total suspended solids, total dissolved nutrients, and herbicide. First, these parameters will be measured separately to study effects of different pollutants on the conductive and capacitive behaviors of water. Combinations of the parameters will then be measured simultaneously using prediction models established based on the frequency-response data. Various pattern-recognition methods, including statistical multivariate analyses and neural networks, will be used to establish the prediction models.

Field tests will be conducted at existing USGS real-time continuous stream and lake monitoring installations with the cooperation of USGS water quality specialists.